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(54) Abstract Title
Pressure sensing devices for pressure or bed sore prevention

(57) The invention relates to a pressure sensing device and also to a matrix of such devices incorporated into a mattress.

There is provided a pressure sensing device comprising a pair of electrical contacts, of which the resistance between the contacts varies according to the pressure applied to the device.

By connecting the one or more pressure devices to a reading means it is possible to obtain a read out of the pressure applied to different regions of the mattress and so assess the likelihood of pressure sores developing.

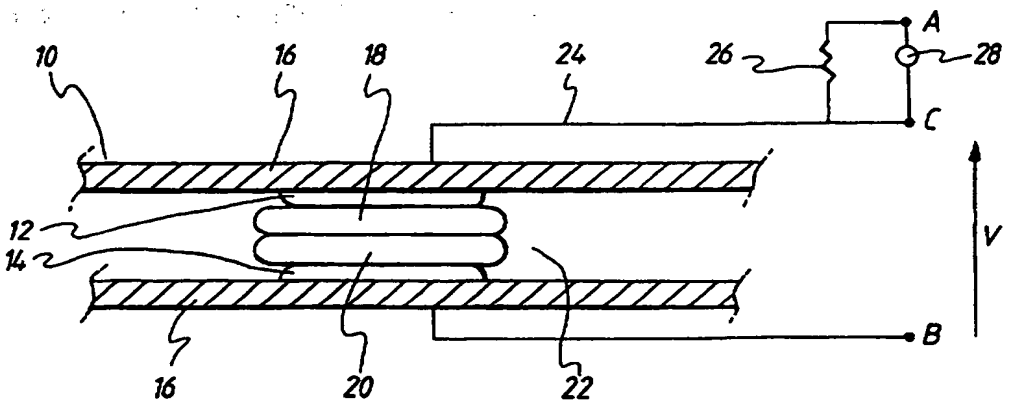

FIG.1

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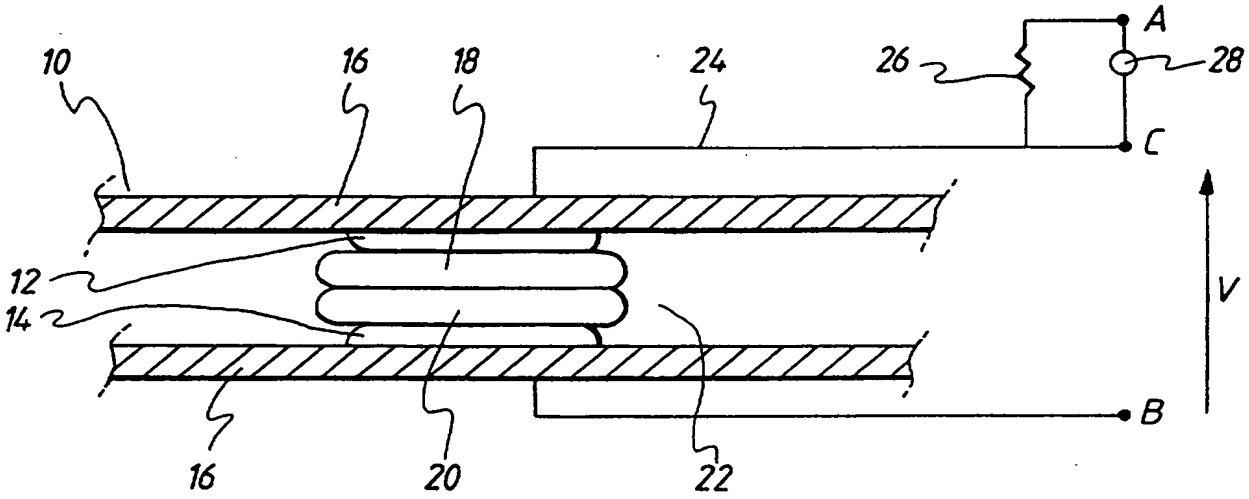
10
16
18
24
26
28
A
C
12
14
V
B
16
20
22

FIG.1

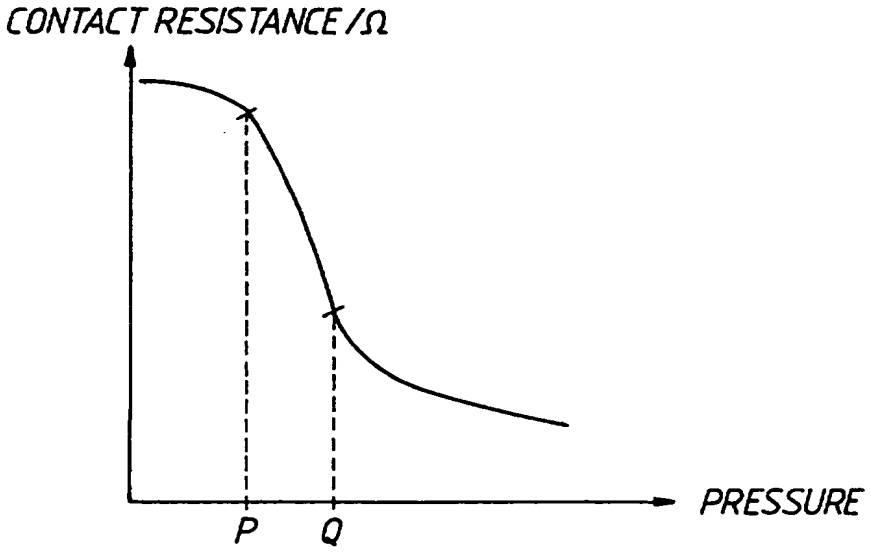
CONTACT RESISTANCE /Ω
PRESSURE
P
Q

FIG.2

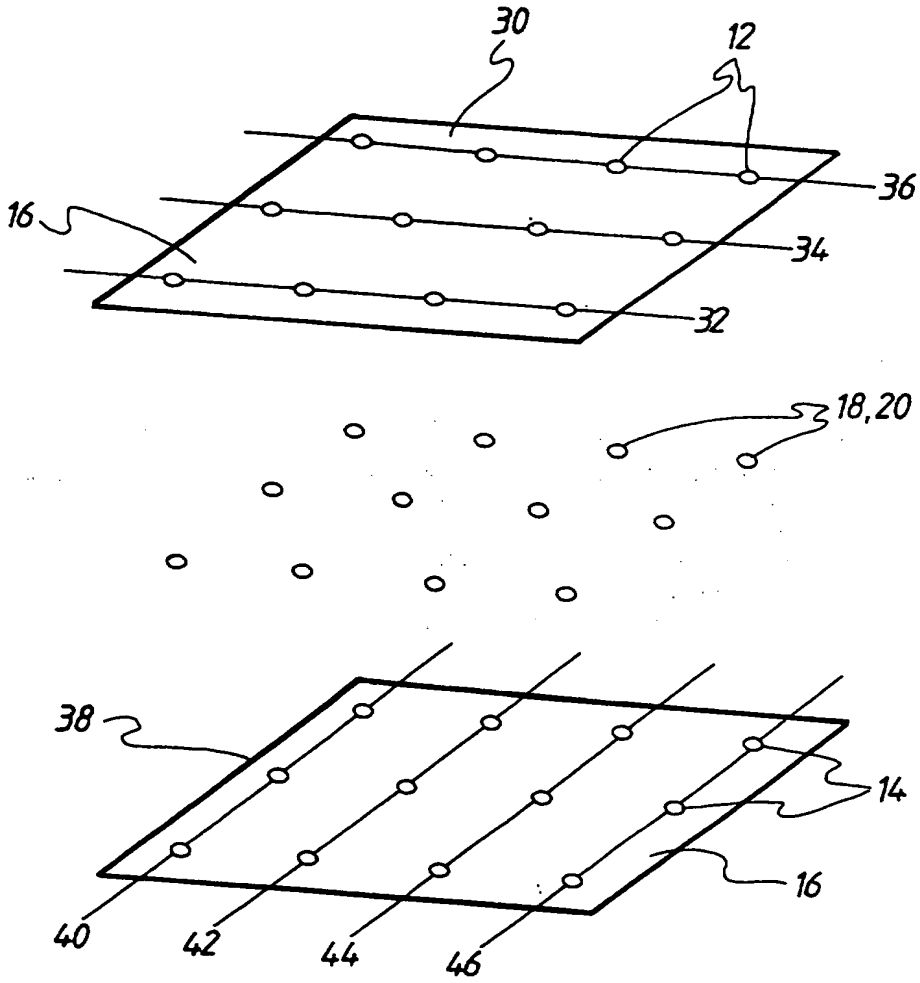

FIG.3

Improvements Relating to Pressure Sensing Devices

The present invention relates to a pressure sensing device and also to a matrix of such devices incorporated into a mattress.

When a person is confined to bed for an extended period of time, it is relatively common for that person to develop bed sores.

The bed sores arise from the person remaining in one position for a lengthy period so that his body weight is concentrated at a few points, putting pressure on those points. At the points on which the body rests therefore, there is a tendency to develop bed sores which can be extremely painful and moreover may easily become infected. It is therefore desirable to prevent the sores from developing and this may be achieved by regularly requesting the patient to move or by turning the patient if he is not capable of movement. However, it is not always easy to determine exactly when the patient should be turned and therefore it is an object of the present invention to provide a method of informing carers when the body weight of a patient has been concentrated on a particular point for an extended period of time.

In a first aspect of the present invention there is provided a pressure sensing device comprising a pair of electrical contacts, of which the resistance between the contacts varies according to the pressure applied to the device.

Preferably the device is arranged so that the contacts touch when no pressure is applied.

Preferably the device is flexible and each contact is mounted on a backing sheet comprising a circuit of conducting

material printed onto a flexible sheet of a plastics material. The conducting material may comprise copper, silver or carbon.

Preferably the contacts are formed from a material having an electrical impedance value at least 1 kilo ohm and this material may comprise a plastics material such as polyvinylchloride impregnated with carbon.

In a second aspect of the invention there is provided a matrix of pressure sensors incorporated into a mattress and connectable to a scanning means such that the pressure distribution between the body of a person lying on the mattress and the mattress can be monitored.

Preferably the sensors are flexible and the matrix is mounted on a backing sheet of flexible plastics material.

Preferably the matrix is mounted on the upper surface of the mattress and there may be holes provided in the backing sheet and the mattress to allow the passage of moisture through the mattress.

There may be an alarm connected to the monitoring system to alert a carer when the body weight distribution of the person lying on the mattress has remained unchanged for a given period of time.

In a third aspect of the invention there is provided a method of measuring the body weight distribution of a prone patient, said method comprising the steps of:-

a) resting the patient on a mattress provided with a matrix of pressure sensors;

b) in a first scanning step, scanning each of the pressure sensors in the matrix to determine whether a load has been placed on that sensor and if so the size of that load, so as to produce a representation of the total body weight of the patient and storing the information in the memory of a computer;

c) in a second scanning step comparing the load measured at each sensor with the total body weight of the patient so as to determine the percentage of the body weight at a particular sensor and comparing the body weight percentage at each sensor with a predetermined danger value above which bed sores are likely to develop;

d) signalling to an operator whether or not the load at each sensor is equal to or exceeds the danger value and storing the information in the computer memory; and

e) triggering an alarm when the pressure at any one sensor has exceeded the danger value for more than a preset period of time.

Preferably the body weight distribution is displayed on a colour monitor with one colour for a pressure equal to or exceeding the danger value and a second colour for a pressure below the danger value.

Preferably the matrix is scanned only once in each scanning operation, the second scanning step comprising scanning the computer memory in order to calculate the percentage of body weight at each sensor and compare this percentage with the danger value.

The invention will now be further described with reference to the accompanying drawings wherein:-

Fig. 1 is a cross section through a pressure sensor according to the invention;

Fig. 2 is a plot of the contact resistance against pressure for the material from which the pressure sensing plates are made;

Fig. 3 is an exploded view showing the construction of the matrix of pressure sensors.

Fig. 1 shows a pressure sensing device 10 comprising two electrical contacts 12, 14, each mounted on a flexible backing layer 16. The backing layer may comprise an insulating plastics material such as polyethylene or acetate and the electrical contacts 12, 14 are printed onto the backing layers so that the pressure sensing device 10 will be flexible. The electrical contact 12 is connected to a plate 18 whilst the contact 14 is connected to a plate 20. The two plates 18, 20 are in surface to surface contact so that an electric current can pass from one side of the pressure sensing device to the other. The plates 18, 20 are made from a semi conducting material having an impedance value of at least 1 kilo ohm and, when the two plates are in surface to surface contact, having a contact resistance which varies linearly according to the pressure applied to the sensor 10.

Fig. 2 shows a plot of contact resistance for the material of the plates 18, 20 against pressure applied to the sensing device and it can be seen that from a maximum when no pressure is applied, the contact resistance decreases gradually until the pressure reaches a value of P. When the pressure has a value in the region between P and Q, the curve is substantially linear and when the pressure is higher than Q, the contact resistance begins to decrease more gradually

until it reaches its minimum value. In order to produce a useful pressure sensing device therefore, it is necessary to manufacture the plates 18, 20 from a material which has a contact resistance versus pressure curve having a relatively long linear portion in a suitable range of pressures. Carbon impregnated PVC has been found to have suitable resistance properties and therefore has been used to manufacture the plates 18, 20.

Between the two backing sheets 16 and surrounding the contacts 12, 14 and the plates 18, 20 is an insulating layer which may comprise for example a waterproof adhesive.

The pressure sensing device 10 is connected into an electrical circuit 24 as shown in Fig. 1 and the pressure applied to the device 10 is represented as the potential difference across points B-C of the circuit. The potential difference across points A-B is known and therefore the required potential difference can conveniently be calculated by connecting a resistor 26 of known value across points A-C and measuring the potential difference across the resistor using the meter 28.

When no pressure is applied to the device 10, the surfaces of the plates 18, 20 will be lightly in contact and the device will have a relatively high resistance. However, as increasing pressure is applied to the device, the plates 18, 20 will be forced together, decreasing the contact resistance between them and thus the resistance of the device 10. As the resistance of the device 10 decreases, the potential difference across points B-C of the circuit will increase and therefore the potential difference across A-C will decrease by a corresponding amount. Since the potential difference across A-B is known, it is simple to obtain the voltage drop across B-C by subtracting the value on the meter 28 from the

voltage drop across A-B. Once this value is known the corresponding pressure value can be determined according to contact resistance pressure relationship defined in Fig. 2.

Fig. 3 shows how a matrix of pressure sensing devices can be constructed. In an upper layer 30, contacts 12 printed onto a flexible backing sheet 16 are joined to one another in rows 32, 34, 36. In a lower layer 38, electrical contacts 14 printed onto a backing sheet 16 are joined to one another in columns 40, 42, 44, 46. Between the two layers are the plates 18, 20 corresponding to each pair of contacts 12, 14. The upper layer 30 and the lower layer 38 are sandwiched together with the plates 18, 20 between them and are incorporated into the top of a mattress. It would of course require more sensors than are shown in Fig. 3 to cover the area of the mattress.

In order to measure the body weight distribution of a person lying on the mattress, the pressure sensor matrix is scanned by a computer controlled scanning means. Each of the sensors in row 32 is scanned and when scanning of this row is completed, the scanner moves onto row 34. As the matrix is scanned, the computer records whether or not any pressure is applied to each sensor and, if so the amount of pressure applied. For each sensor which is pressurised, the computer places a flag in its memory. Since the computer has scanned the total number of pressure sensors to which pressure is applied and the pressure applied to each of the sensors, it is a simple matter to calculate a figure B representing the total body weight of the person resting on the mattress. If the total number of sensors to which pressure is applied is represented by the letter N then an average figure for body weight distribution can be represented by B/N.

An operator inputs into the computer a danger value

representing a proportion of the total body weight which, if applied at any one sensor, would be likely to cause a bed sore on the part of the patient's body corresponding to that sensor, if the pressure were maintained for more than a certain length of time. A second scanning step is then carried out in which the computer scans the pressure figures for each sensor stored in its memory, compares them with the danger value which has been set and transmits the results to a visual display. Sensors on which the pressure applied is less than the danger value will be represented in one colour, for example green whilst sensors at which the applied pressure is greater than or equal to the danger value will be represented in a second colour, for example red. As well as transmitting the results of this second scan to a visual display, the computer will also store them in its memory and will set up a second flag at each sensor where the applied pressure is greater than or equal to the danger value. For each sensor at which the computer has stored two flags in its memory, i.e. noted that there is a pressure applied at this sensor and that the pressure is greater than or equal to the danger level, the time will be noted at which the second flag was entered into the memory. The scanning process is iterative and therefore the results are constantly updated. However, if a sensor has been marked by the computer with two memory flags for a time exceeding a danger time set by the operator, the computer may be programmed to sound an alarm telling the patient to move. If two flags continue to be recorded in the memory for the same sensor, the computer may then sound a second alarm which will alert medical staff or other carers so that the patient can be moved.

The present invention therefore monitors the weight distribution of the person lying on a mattress and warns both the patient and the carers when the patient has remained for too long in one position and is therefore likely to start

developing bed sores. The invention avoids the need for constant supervision of each patient and thus relieves pressure on medical staff. Moreover, the sensors described in this invention are relatively inexpensive and can relatively easily be combined to form a matrix so that the mattress described in the invention is easy to construct.

CLAIMS

1. In a bed at least one pressure sensing device for measuring pressure applied to same, the device being connected to a reading means for monitoring pressure applied to at least one area of a bed.

2. A bed according to Claim 1 wherein the device comprises the deformable means connected to an electrical contact means wherein the resistance between the contact means varies according to the pressure applied to the deformable means.

3. A bed according to Claim 2 wherein the deformable means comprises at least one pressure sensitive plate.

4. A bed according to Claim 2 wherein the deformable means comprises two adjacent pressure sensitive plates and a pair of electrical contacts positioned to provide current flow between the two plates.

5. A bed according to Claim 4 wherein the contacts are arranged to touch when no pressure is applied.

6. A bed according to claims 2 to 5 wherein the contact means is mounted on a backing sheet comprising a circuit of conductive material printed on a flexible sheet of plastics material.

7. A bed according to claim 6 wherein the conducting material is copper.

8. A bed according to claim 6 wherein the conducting material is silver.

9. A bed according to claim 6 wherein the conducting

material is carbon.

10. A bed according to claims 2 to 9 wherein the contacts are made from a material having electrical impedence value of at least 1 kilo ohm.

11. A bed according to claim 10 wherein the contacts are made from a plastics material.

12. A bed according to Claim 11 wherein the plastics material comprises polyvinylchloride impregnated with carbon.

13. In a bed an arrangement of pressure sensing devices, each device being connected to at least one reading means so as to provide an indication of pressure applied to different areas of the bed in which each of the pressure senses are located.

14. A bed according to claim 13 wherein the arrangement of sensors is connected to a scanning means so as to enable selective scanning of the sensors.

15. A bed according to claim 13 or 14 wherein the sensors are mounted on a backing sheet.

16. A bed according to claim 15 wherein the backing sheet is made of plastics material.

17. A bed according to claim 13, 14, 15 or 16 wherein the arrangement of sensors is mounted on the upper surface of the bed.

18. A bed according to claim 14 to 17, wherein holes are provided in the backing sheet to allow the passage of moisture therethrough.

19. A bed according to any preceding claim wherein an alarm is connected to the reading means so as to generate an alarm signal when at least one pressure device registers a pressure above a pre-determined acceptable level.

20. A bed according to any preceding claim wherein the reading means comprises a monitor adapted to display a representation of the bed wherein the display comprises indications as to the pressure applied to different areas of the bed.

21. A bed according to claim 20 wherein the monitor is a colour monitor and differentials in pressure are expressed according to a pre-selected spectrum of at least one colour.

22. A bed according to any preceding claim wherein the reading means is connected to a control means which calculates the percentage of body weight resting on each activated sensor so as to indicate pressure points.

23. A bed as substantially herein described with reference to the accompanying drawings.

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Application No: GB 9912224.4 **Examiner:** Eamonn Quirk
Claims searched: 1-23 **Date of search:** 27 September 2000

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Int Cl (Ed.7): A61B (5/103, 5/11) G01B(7/28) G01L(1/20) G06K(11/12) H01H(3/14)

Other: Online: WPI, JAPIO, EPODOC.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X, P	GB 2 343 516 A	(Brunel University) pages 1 and 2	1, 2, 13
X	GB 2 329 250 A	(Doughty) whole document	1, 2, 13
X	GB 2 320 759 A	(Pegasus Airwave) see figures	1,13
X	EP 0 136 247 A	(Brig Research)	1,13
X	WO 98/34577 A1	(Lewin Herbert)	1,13
X	US 5 253 656	(Moore) figures 1 and 2	1,13
X	US 4 172 216	(Sprague Electric)	1,13
X	US 3 836 900	(Fleet Electronics) see figures	1,2,13
A, P	WPI Acc. No. 2000-213427 & JP110342161 A (Nippondenso) see WPI abstract		

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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